Real Time Monitoring of Sludge Rheology during gas Injection.

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ABSTRACT

A Commercial rheometer was used in-situ to analyze the real time Triphasic rheological Characterization of waste activated sludge during gas injection. The effect of gas injection on rheological parameters was studied for both centrifuge and then diluted sludge and on raw sludge coming directly from waste water treatment plant. It was observed that the influence on viscosity because of gas injection is more evident in low shear rate region (below $10s^{-1)}$ and reaching a plateau at higher shear rate. On comparing the results for both the type of sludge with same gas flow rate and same shear rate range no considerable change in viscosity was observed. The effect of gas flow rate at same concentration shows that an increase in gas flow rate leads to not only decrease in apparent viscosities but also change in sludge flow properties.

Key words: - Triphasic rheological properties, Activated sludge, In-situ operation, commercial rheometer.

INTRODUCTION

For optimization and an efficient operation of any process unit, rheological properties play an important role. Sludge has a very complex nature; its properties undergo continuous change during treatment process, especially during aeration. Understanding of real time sludge rheological properties during aeration allows to optimize the performance of unit operations like pumps and mixers, which are vital at any treatment plant (Baudez et al. 2011; Eshtiaghi et al. 2013; Ratkovich et al. 2013; Slatter 1997).

So far all the studies investigated the change of flow properties of sludge with respect to the effect of variables such as pH, conductivity, and temperature and solids concentration ex-situ with a very little information available on the change of sludge rheology with gas injection. The dynamics of gas phase have a significant influence on fluid properties and mass transfer rates.

This paper particularly focuses on real time measurements of triphasic rheological properties using commercial rheometer and describes the impact of gas injection on waste activated sludge rheology on both centrifuge and then diluted and raw sludge coming directly from waste water treatment plant with different gas flow rate (0.08 L/min to 0.5 L/min)

MATERIAL AND METHODS

The sludge used in this work comes from Eastern treatment plant in Victoria, Australia. Waste activated sludge has a concentration of 2.6 % which is centrifuged and then diluted with deionized water to the desired concentration. The Nitrogen gas is injected in order to study the influence of gas flow rate on sludge rheology. The gas flow rate is varied from 0.08 L/min to 0.5 L/min. The flow curve was measured in-situ for 2.3% and 2.6% sludge concentration at 6 different gas flow rate in the abovementioned range using HR3 rheometer at a shear rate range of $0.01 – 100\ s^{-1.}$

RESULTS AND CONCLUSIONS

The apparent viscosity of aerated sludge as a function of shear rate was plotted (in the log-log scales) in order to better understand the impact of gas injection on sludge rheology. The results (shown in Figure 1) showed the decreasing viscosity of sludge by increasing gas injection flow rate at low shear rate ($<10S^{-1}$) while it was independent of gas flow rate at higher shear rate. Also Table 1 reveals the change in sludge flow properties.

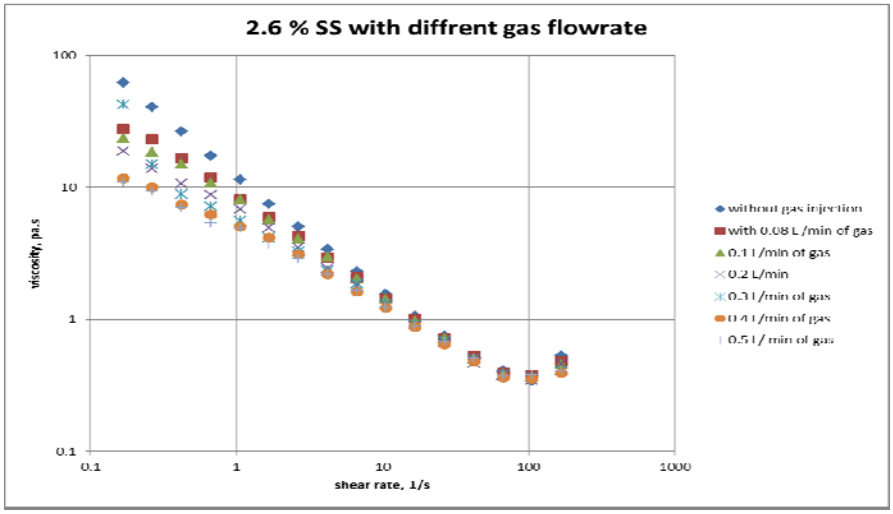

Figure 1: 2.6% Secondary sludge apparent viscosity with different gas flow rate

Table 1: Change in shear thinning properties of 2.6% secondary sludge at different gas flow rates

Gas Flow Rate (L/min)	Flow consistency Index , k ($Pa.S^n$)	Flow Index, n	Herschel Bulkley Yield stress (Pa)
0	0.27	0.9	12.3
0.08	4.71	0.42	3.2
0.1	6.65	0.34	0.83
0.2	5.76	0.37	0.35
0.3	5.40	0.39	0.39
0.4	4.73	0.41	0
0.5	4.48	0.44	0

Conclusion

- The effect of gas injection on the viscosity is important at low shear rate.
- The decrease in viscosity due to the gas injection at low shear rate increases with increase in gas flow rate and then remains constant.
- A very little change in viscosity is observed above a shear rate of 10 s^{-1} regardless of gas flow rate.

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